Charmed Meson Reconstruction using Silicon Trackers in STAR Experiment at RHIC

- Motivation
- STAR Detector
- Microvertexing
- Results
- Summary and Future

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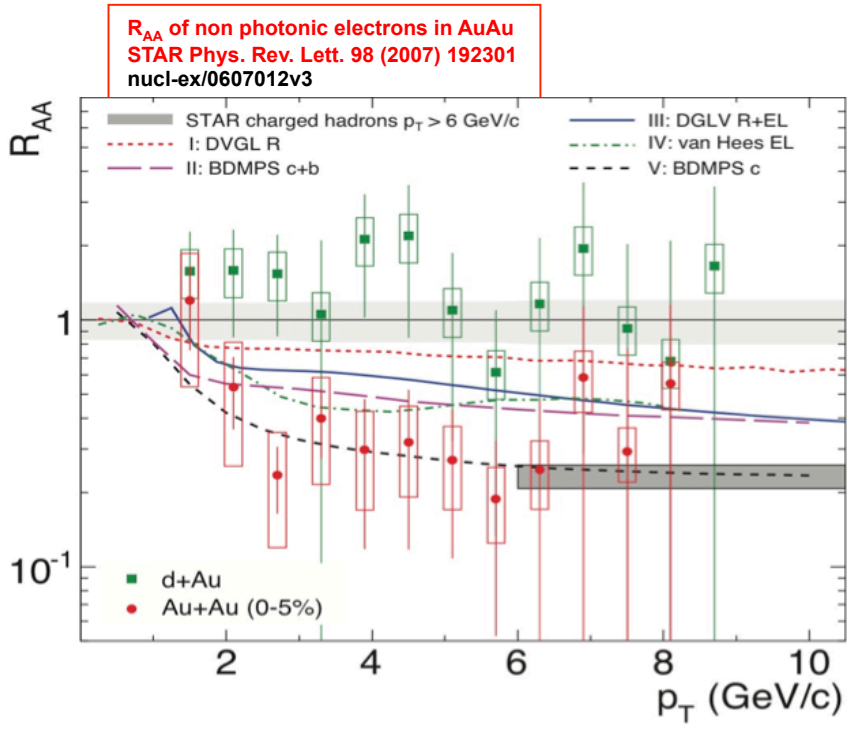
Why Charm Mesons?

❑ **Heavy quarks are produced during the early stages of collision mainly through gluon fusion.**

- ❑ They are unaffected by chiral symmetry restoration
- ❑ Their production cross-section scales with binary collisions

Heavy quarks are ideal to probe the medium created in HI collisions.



❑ Their Measurement through semi-leptonic decay channel shows suppression levels comparable to light quarks at $p_T \geq 6$ GeV[1]

$R_{AA}(n.p.e.) \sim R_{AA}(h^{\pm})$!

❑ This contradicts theoretical predictions

- ❑ Dead-cone effect[2]

❑ A Measurement of charm elliptic flow, v_2 can tell us if thermalization is reached during early stages of collision.

Need to understand the Mechanism of parton energy loss and Thermalization

[1] Adare A et al. (PHENIX Collaboration) 2010 arXiv.org arXiv:1005.1627
*[2] Dokshitzer, Yuri L. and Kharzeev, D. E., Phys. Lett. B**519***

Measurement through Indirect & Direct Methods

Indirect Measurement through Semi-leptonic decay channels:

- $D^0 \rightarrow e^+ + X$ (BR : 6.9 %)
- $D^{+/-} \rightarrow e^{+/-} + X$ (BR : 17.2%)
- $D^{*+} \rightarrow e^+ + X$ (BR: 6.9%)

✔ Large pT range.
✔ Relative contribution of electrons from B and D mesons are unknown.

Direct Measurement through Hadronic decay channels

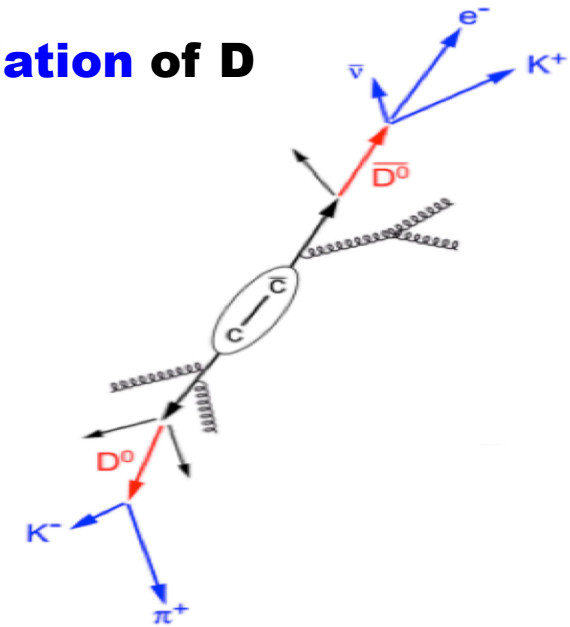
- $D^0(\overline{D^0}) \rightarrow K^-\pi^+(K^+\pi^-)$ (BR : 3.8 %)
- $D^{+/-} \rightarrow K\pi\pi$ (BR : 9.2%)

✔ Limited to low momentum range.
✔ C and B contributions separated.
✔ Challenging for charm mesons due to small decay length

Measurement using azimuthal correlation of D mesons with e^-

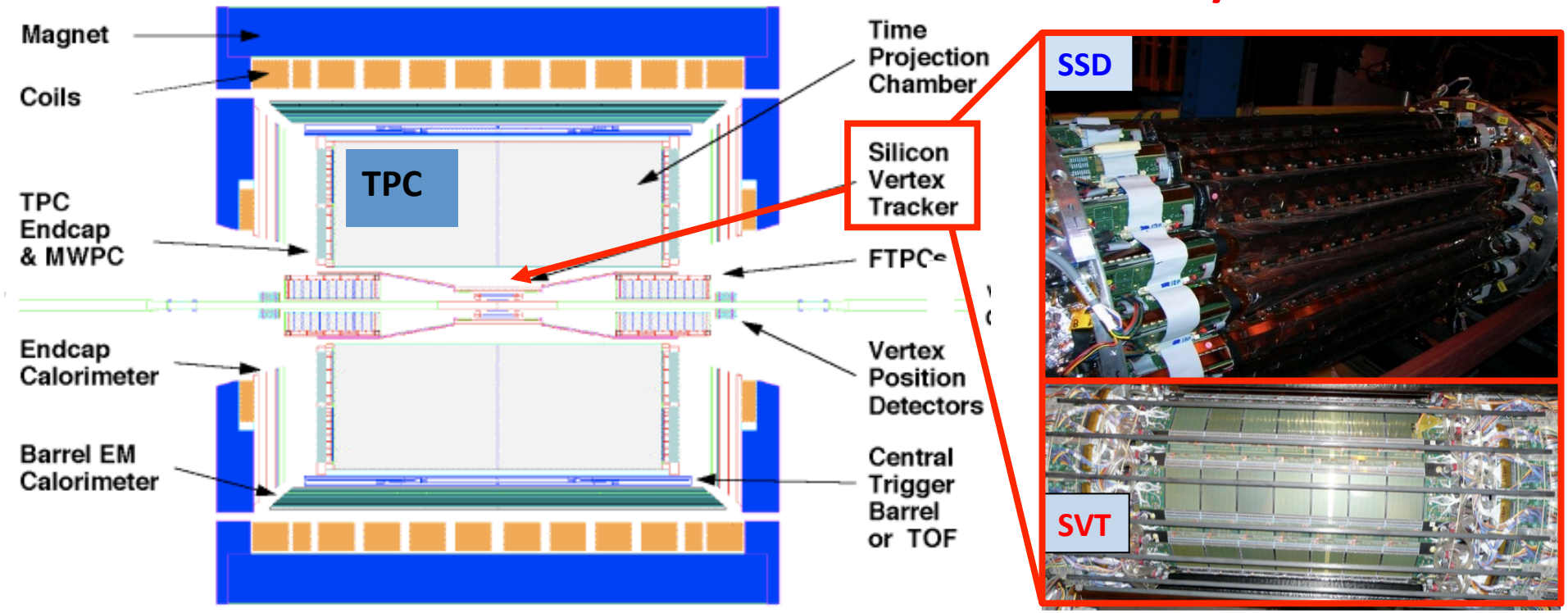
Azimuthal correlation of open charm mesons with non-photonic Electron can be utilized to disentangle the charm and bottom contributions[3]

✔ Triggers on high pT electrons



[3] Phys. Le.. B671(2008) 361, Phys. Rev. Le.. 105 (2010) 202301

STAR detector (in 2007)



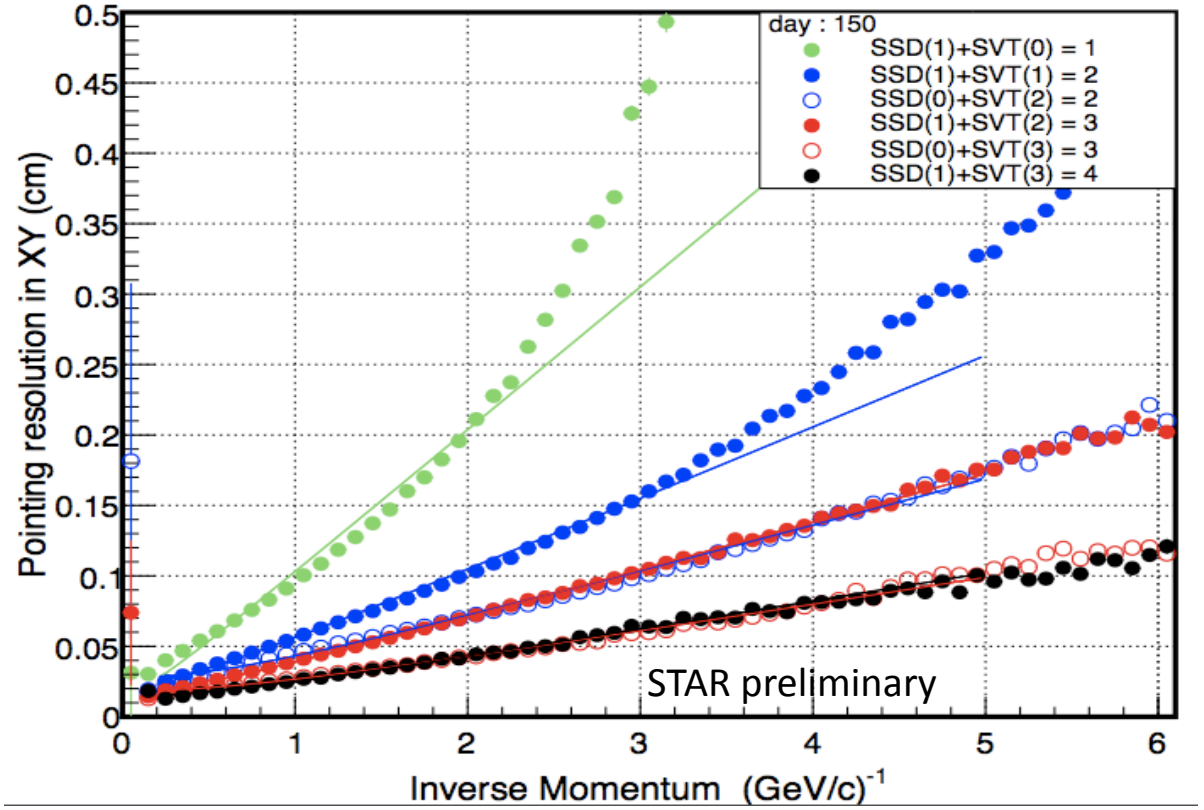
The tracking system consisted of :

- **TPC :** provides momentum, particle identification
- Silicon detectors :
  - 1 layer of silicon **strip** detectors (**SSD**) and 3 layers of silicon **drift** detectors (**SVT**).
  - **high spatial resolution** : pointing resolution of 250μm in transverse direction (at 1GeV) was achieved[*] (next slide).
  - was not designed (thickness, geometry) for charm measurement.

[*] Fisyak Y V et al. 2008 J. Phys. Conf. Ser. 119 032017

Distance of Closest Approach resolution

- run 7 Au+Au@200GeV (MinBias trigger).
- DCA resolution as a function of inverse momentum.
- Reflect the resolution and Multiple Coulomb Scattering.



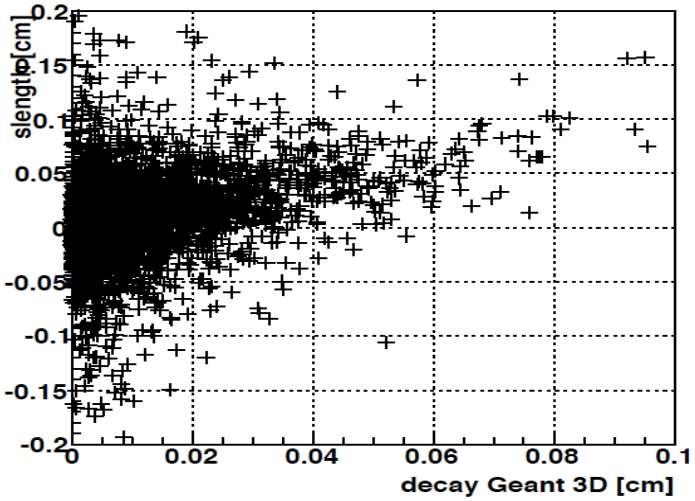
➔Including the silicon detectors in the tracking improves the pointing resolution.

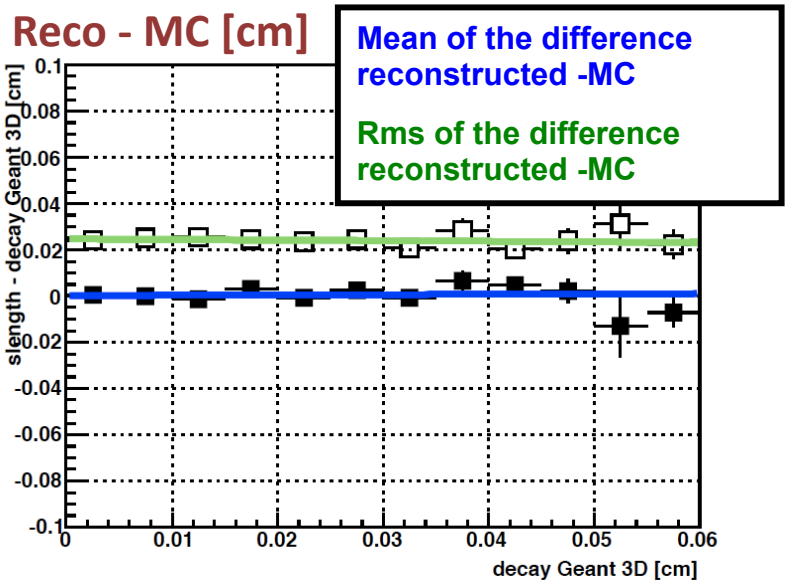
➔with 4 silicon hits, the pointing resolution to the interaction point ~ 250 mm at P = 1GeV/c.

Microvertexing using STAR Silicon Detectors

✧ We tried a **Full Topological reconstruction** of the charm decay. The method uses a constrained fit for decay vertex reconstruction[*]

✧ The code uses full track/error information.

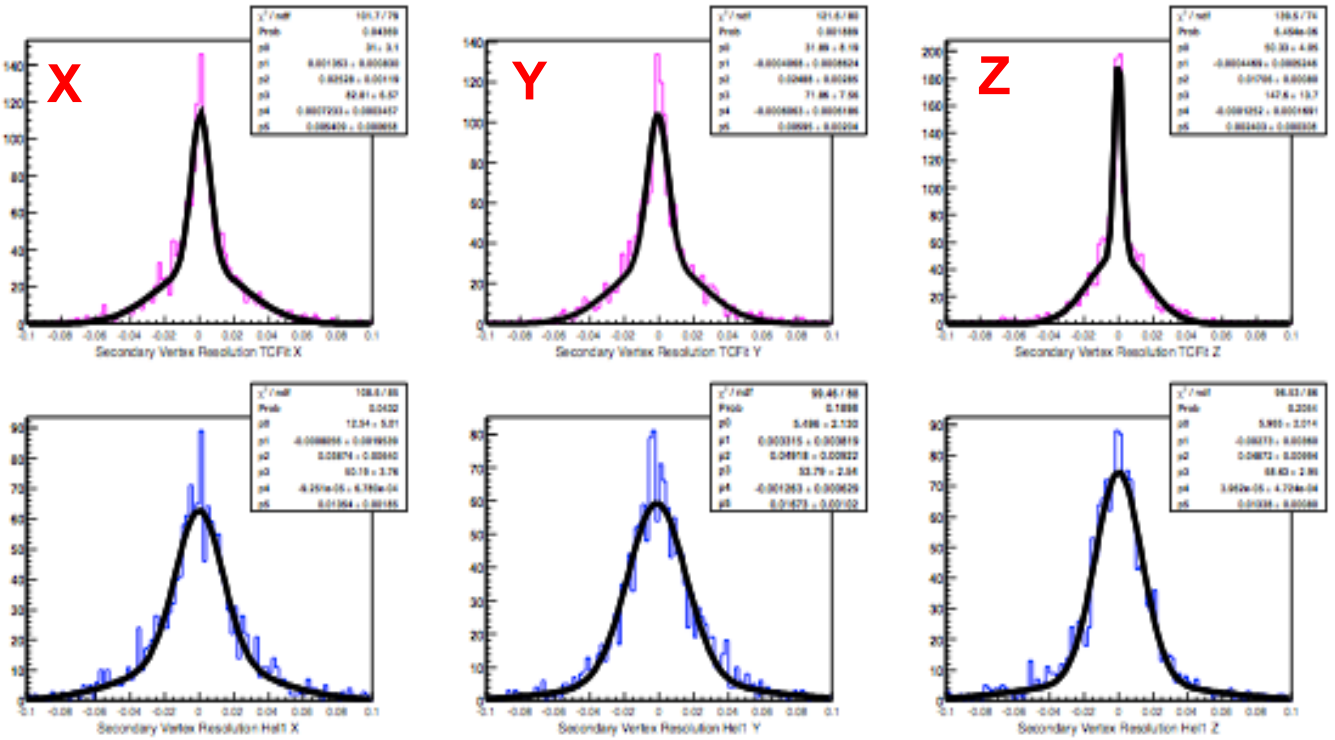




- There is no systematic shift in reconstructed quantities.
- The standard deviation of the distribution is flat at ~ 250 μm , which is of the order of the resolution of (SSD+SVT).

[*] Decay Chain Fitting with a Kalman Filter,W. D. Hulsbergen (arxiv:physics,0503191)

Secondary Vertex Resolution Plots (x,y,z)



Fit

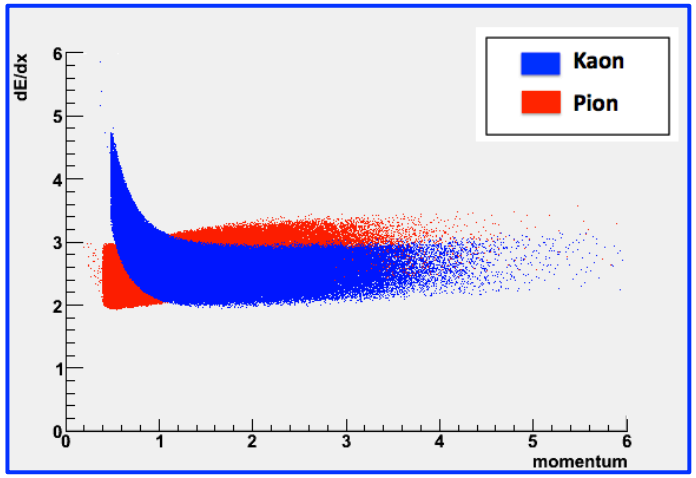
Helix Swimming Method

Simulation results shows that a factor of two was gained in secondary vertex Resolution

D^0/D^0bar Cross-feed

(Monte Carlo using power law p_T D^0)

- The D^0 candidates are built by combining a K^- and π^+ track ($D^0 \longrightarrow K^-pi^+$)
- Because of the overlapping dE/dx bands of Kaon and Pion tracks, at intermediate momenta

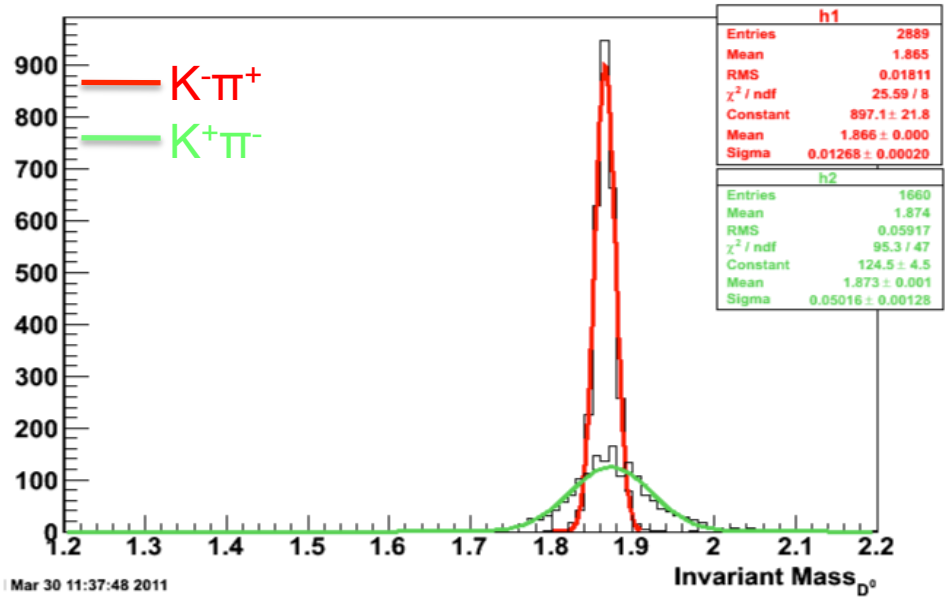


➔ a K^- can be indentified as π^-

➔ a π^+ can be identified as a K^+

➔ Therefore, $K^-\pi^+ \longrightarrow K^+\pi^-$ and can contribute to the the D^0bar mass window and a pseudo-enhancement.

- The X-feed is reduced
  - with a tighter cut on |nσ| (better PID)
  - with increase in p_T
- X-feed has a strong dependence on the Kaon opening angle, Cos(θ*)



The estimated overall X-feed (Ratio of reconstructed pairs with wrong signs to all pairs) ~ 35%

Data Production

Initial production over the Au-Au dataset (34 Million Events) was done. Although the cuts used were not optimized, we got preliminary results from this production. A new production of the entire run-7 data was just completed. Analysis is in progress.

Highlights of Au+Au data set re-production

✧ With all charge combinations saved (D0, D0bar**, ++,-- pairs**)

✧ **Calculation of v2 (flow) (Save Event plane, D0 phi angle).**

✧ Select only Triggered Events (Pile-up events are removed).

✧ Tracks with SiHits>1 are selected

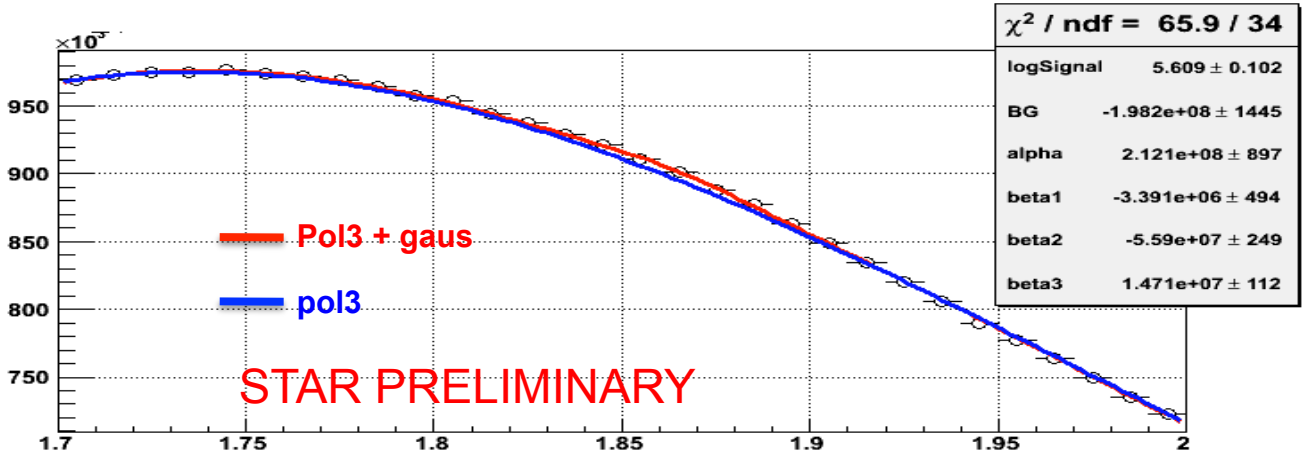
✧ **gRefMult properly calculated/saved**

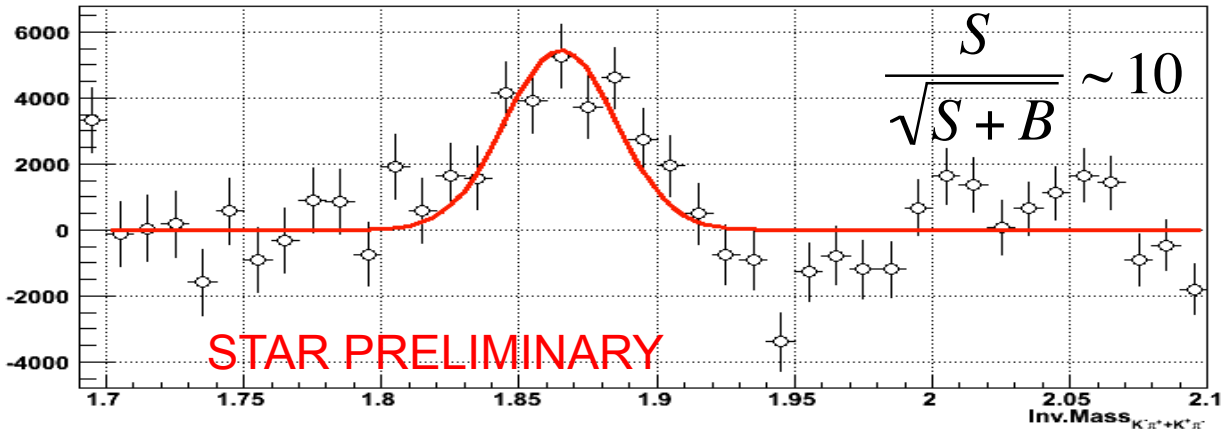
✧ Track Momentum cut was modified to preserve the phase space of the candidates better

✧ dEdx cut was modified: $|n\sigma_K|<2.5$ and $|n\sigma_\pi|<2.5$

✧ Released the cut on track pseudorapidity to $|\eta|<1.2$ and added a cut on rapidity of D0 **(|Rapidity|<1**).

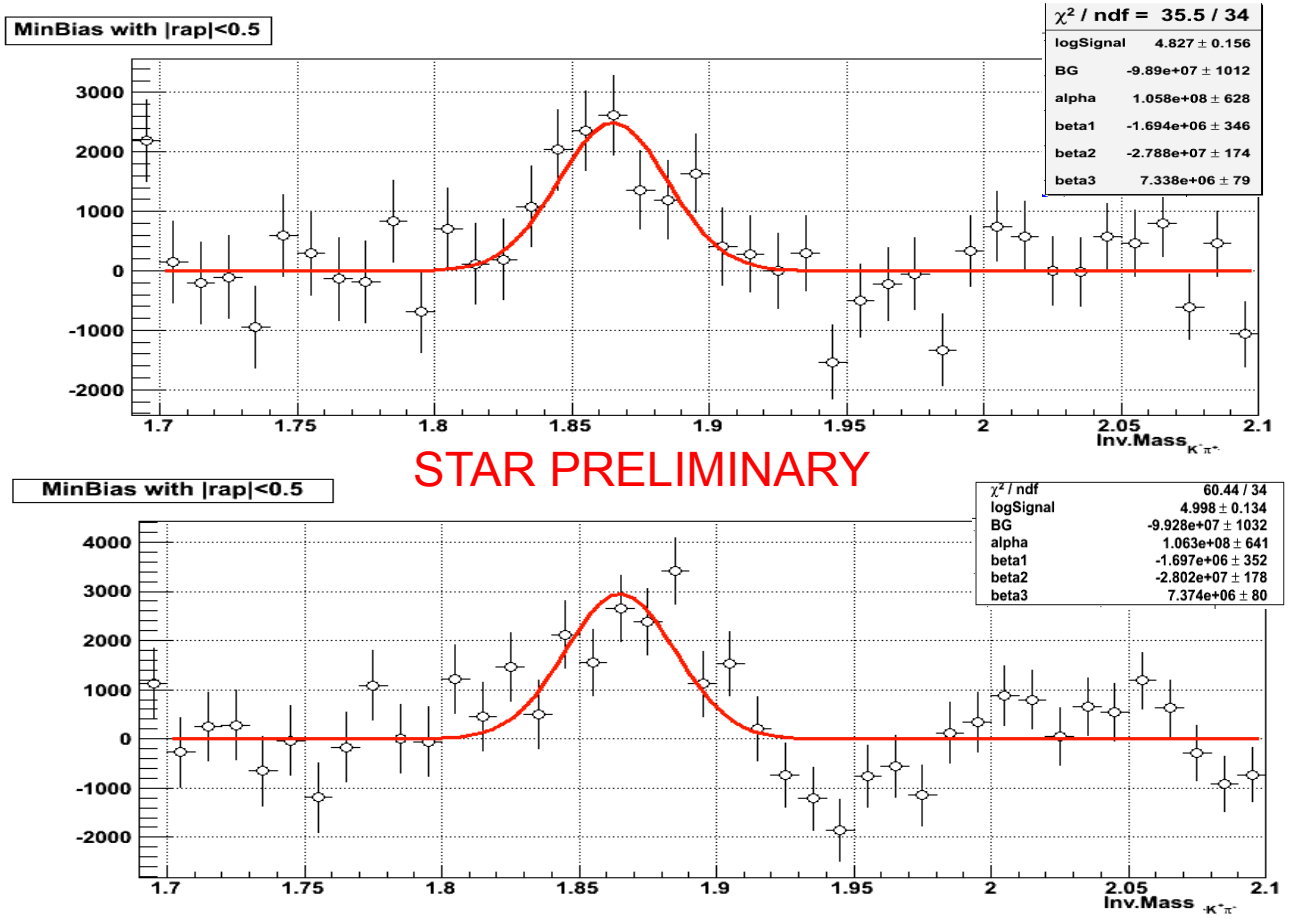
D^0+D^0bar signal in 2007 Data (MinBias Files)





- 34 Million Events used for this analysis.
- Kinematic fit yields an improved significance of 10σ for combined D^0+D^0bar.
- The signal is somewhat sensitive to the degree of the pol. Fit.
- Need a robust backgr. estimation method (new production)

D^0 and D^0bar separately



Preliminary D0bar/D0 ratio ~ 1.05±0.19(stat.)

Summary

- We present progress on a method for full Topological reconstruction of open charm mesons.
- Ongoing efforts to measure cross-section (with smaller errors) and some D^0 flow(v_2)
- Method developed is baseline for analyses involving the future upgrade of STAR – Heavy Flavor Tracker (HFT), which will provide unambiguous measurement of charm.

Thank you

Back-Up

2007 Production MinBias

- cut changed
- new cut

Cuts from Previous Production

EVENT level

triggerId : 200001, 200003, 200013
Primary vertex position along the beam axis :
|zvertex| < 10 cm
Resolution of the primary vertex position along the beam axis:
$|\sigma_{zvertex}| < 200\mu m$

TRACKS level

Number of hits in the vertex detectors :
SiliconHits>2 (tracks with sufficient DCA resolution)
Transverse Momentum of tracks:
p_T >.5GeV/c
Momentum of tracks:
p >.5GeV/c
Number of fitted:
TPC hits > 20
Pseudo-rapidity :**|η|<1** (SSD acceptance)
dEdxTrackLength>40 cm
DCA to Primary vertex (transverse),
DCA_{xy}< .1 cm

Cuts in New Production

EVENT level

triggerId : 200001, 200003, 200013
Primary vertex position along the beam axis :
|zvertex| < 10 cm
Resolution of the primary vertex position along the beam axis:
$|\sigma_{zvertex}| < 200\mu m$

TRACKS level

Number of hits in the vertex detectors:
SiliconHits>1
Transverse Momentum of tracks:
p_T >.5GeV/c
Momentum of tracks
pK+pPi >1.5GeV/c
Ratio TPC hits Fitted/Possible > 0.51
Pseudo-rapidity :**|η|<1.2**
dEdxTrackLength>40 cm
DCA to Primary vertex (transverse),
DCA_{xy}< .2 cm
Radius of first hit on track :
< 9 cm if number of silicon hits =2
< 13 cm else

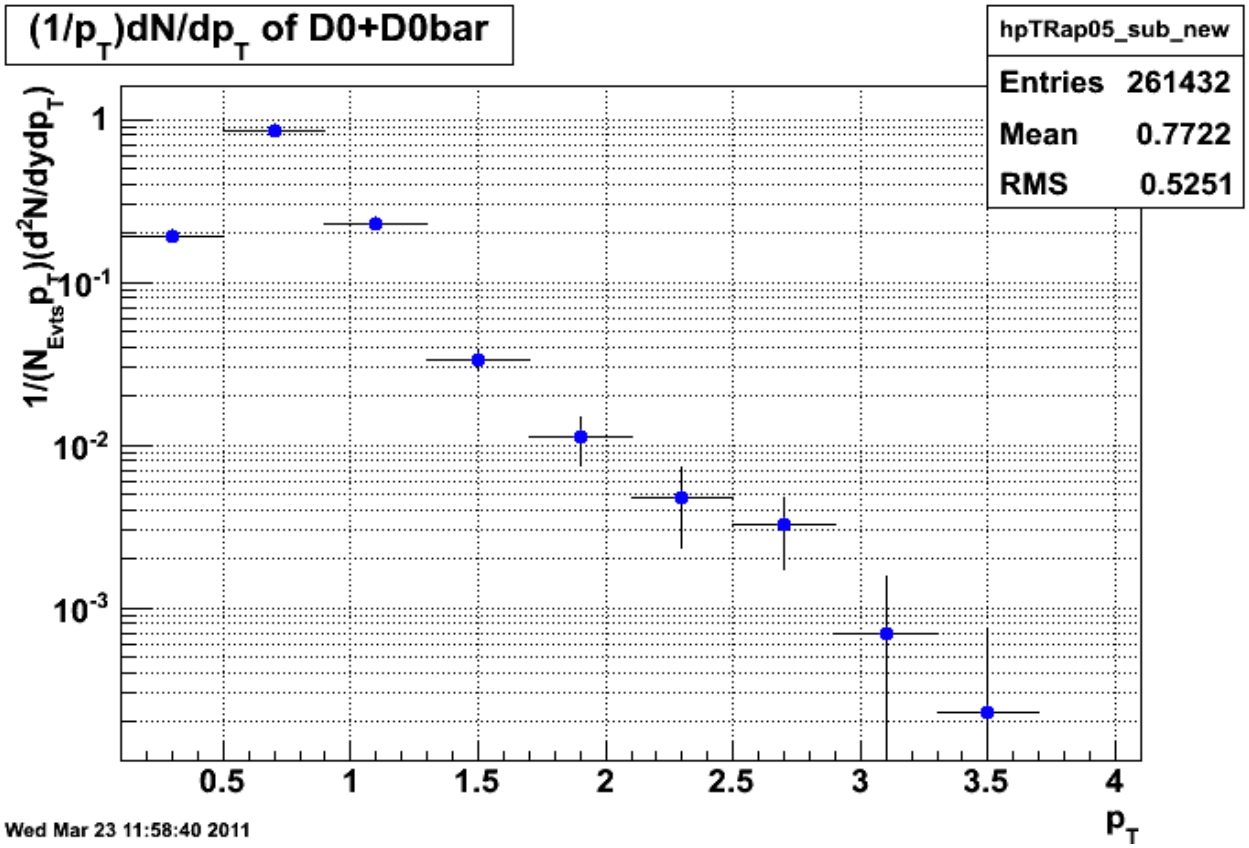
Continued..

Cuts from Previous production	Cuts in New Production
	D^0 candidate $\|y(D^0)\|<1$ $\|\cos(\theta^*)\|<0.8$
DECAY FIT level	**DECAY FIT level**
Probability of fit >0.1 && |sLength|<.1cm	**Probability of fit >0.01 && |sLength|<.1cm**
Particle ID : ndEdx : $\|n\sigma_K\|<2$, $\|n\sigma_\pi\|<2$	Particle ID : ndEdx : $\|n\sigma_K\|<2.5$, $\|n\sigma_\pi\|<2.5$

In both productions we made a pico file for further analysis.

D^0 –p_T distribution

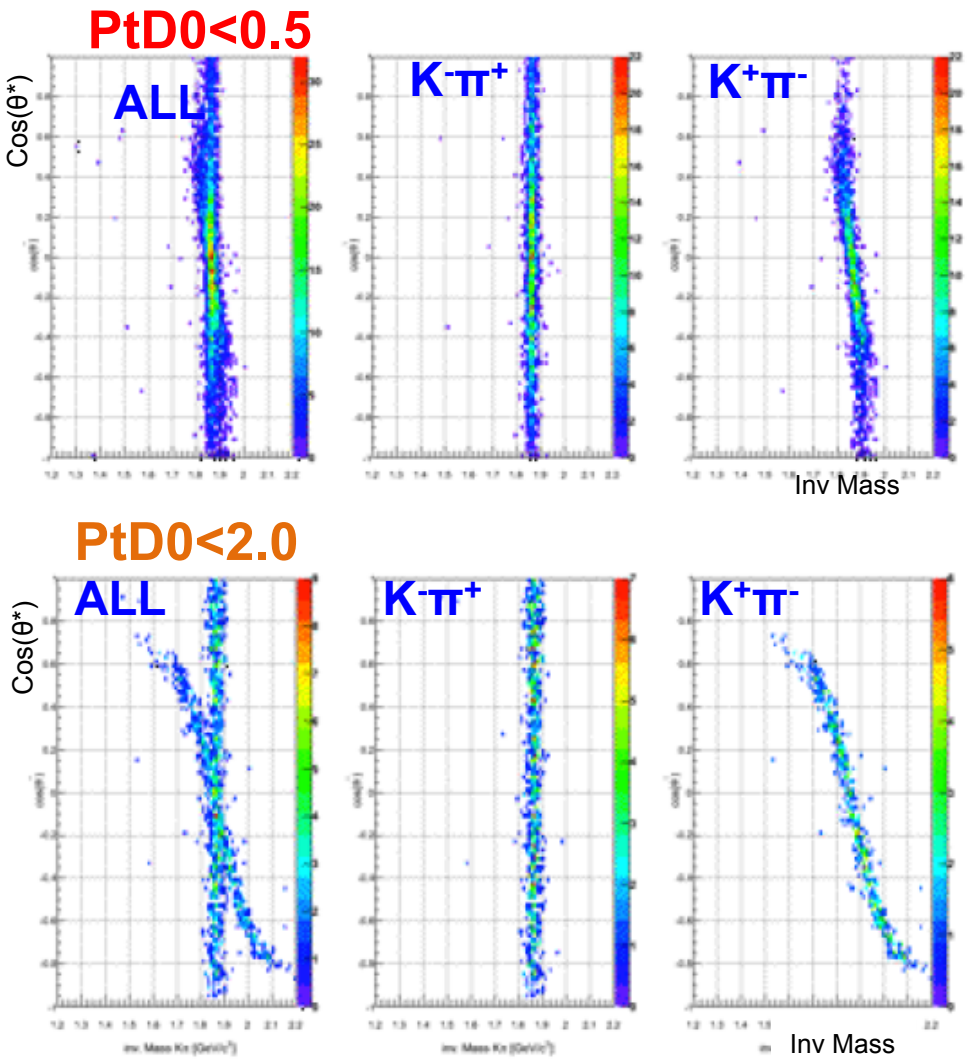
$$\frac{1}{N_{Events} p_T} \frac{d^2 N}{dy dp_T}$$



Uncorrected p_T spectra for D^0+D^0bar

D^0 p_T is done by subtracting from the central mass peak the normalized sum of the side bands.

Cross-feed Vs Kaon Opening Angle in the CM frame



For Low Pt_{D0}:

Both true pairs and misidentified pairs have the distribution going from -1 to 1

For High PtD0:

The true pairs have the same distribution(-1,1)
Misidentified pairs have shortened tails (-0.8,0.8)

The Cut* |Cos(θ*)|<0.6, can be limited to the low p_T D^0s.

* *The cut |Cos(θ*)|<0.6 removes the poorly reconstructed soft tracks*.